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Education Department Bulletin

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No. 519 ALBANY, N. Y. May 15, 1912

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 160

THE GLACIAL WATERS

IN THE

BLACK AND MOHAWK VALLEYS

BY

HERMAN L. FAIRCHILD

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New York State Education Department
Science Division, September 9, 1911

Hon. Andrew S. Draper LL.D.
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SIR: I have the honor to transmit to you herewith the manuscript and maps of a report entitled *The Glacial Waters in the Black and Mohawk Valleys,* prepared by Doctor Herman L. Fairchild, a member of the staff of this division, in continuation and completion of his study of the development of the water system of the State, and I recommend that it be published as a bulletin of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

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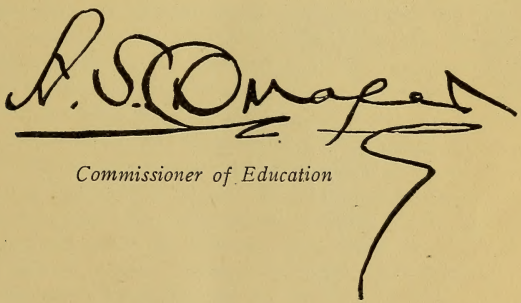
Approved for publication this 12th day of September 1911



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John M. Clarke, Director

Museum Bulletin 160

THE GLACIAL WATERS

IN THE

BLACK AND MOHAWK VALLEYS

BY

HERMAN L. FAIRCHILD

INTRODUCTION: OUTLINE OF THE GLACIAL HISTORY

This paper is essentially a continuation of the one forming State Museum Bulletin 127, "Glacial Waters in Central New York." In that paper was given the history of the glacial lakes and the ice-border drainage as far east as Oneida. While the features there described are quite clear as to their origin, the relationship of the phenomena in time and causality are somewhat uncertain, in the present state of our knowledge of the behavior of the ice margin during its recession across the State. It was there stated that the oscillations of the glacier were probably greater and the history more complicated than now recognized. In the present writing there is similar complication, with the additional problem of correlating the sequence of events in the Ontario basin with those in the Mohawk and Hudson valleys. For the Black river basin the history is comparatively clear, but not so for the Mohawk-Hudson. The writer aims to give an outline of the dramatic history and lay the foundation for future detailed work.

The study of the Black valley was mainly during the summers of 1907 and 1908, though some features had been noted in earlier years. It was the intention to submit the matter for publication in 1908 but the need of revision of the Watertown sheet caused delay and it is included here.

A concise outline of the history described in the following writing will be helpful to the reader. As the large physiographic relief we have the elevated tract of the Adirondacks surrounded by low and broad valleys; the Champlain-Hudson on the east, the Mohawk on the south, the Ontario on the southwest and west, and the St Lawrence on the northwest and north. The highest point in all this ring of lowland is the col at Rome, about 430 feet above tide, the head of the Mohawk valley which is the connecting channel between the Ontario and Hudson valleys.

As the Labradorian ice body, which had at its maximum covered practically the entire State, waned and lost in thickness the Adirondack heights appeared above the ice field, standing as an island in the ice sheet, although local or stream glaciers probably occupied for a time some of the higher valleys. The high Catskill-Helderberg mass must have already been deserted by the ice sheet, and consequently there was left a strait or neck of ice in the Mohawk valley connecting the Ontarian and Hudsonian ice lobes. This stage in the ice retreat is shown in plate 12.

The removal of the ice was partly by evaporation but chiefly by melting and water must have collected about the base of the Adirondack island, forming a chain of lakes in the depressions. This water would fill all the crevasses in the ice margin and to some extent would penetrate in and beneath the shallower ice, but it is not believed possible for the water to have found escape through or beneath the deep ice which lay in the Ontario and Hudson valleys. Its only possible ultimate escape must have been over and across the strait of ice south of the Adirondacks. Some of the extensive sand plains, even in the heart of the mountains and with altitude over 1400 feet, must belong to this episode in the drainage.

With the continued waning of the ice body the neck of ice in the Mohawk valley was melted away and was supplanted by a lake held between the two opposing ice lobes, the Hudsonian lobe pushing up the Mohawk valley from the east and the Ontarian lobe blocking the valley on the west. This stage is shown in plates 13–15.

The Mohawk glacial waters were lowered and finally extinguished by the weakening and recession of the Hudsonian ice in the vicinity of Schenectady (see plates 14–16).

Contemporary with the Mohawk glacial waters were waters held in the valley of the Black river by the ice blockade on the north, with earlier outflow southward into the Mohawk lakes. The later escape of the Black waters was westward into Lake Iroquois, in the vicinity of Copenhagen and Carthage (see plate 17).

The glacial lake history of the Mohawk valley must have been contemporaneous with only the earlier glacial waters in central New York, lakes Watkins and Newberry (see no. 19 of the bibliographic list, Bulletin 127, and plates 34, 35), for the reason that the central New York waters of later time found free eastward escape through the Mohawk valley at the lowest levels.

Doubtless there were readvances and reretreats of the ice fronts and restorations of the lakes which we can not now recognize, but finally the Ontarian ice permanently receded from the Oneida-Rome district and Lake Iroquois was established with its long-continued outlet at Rome to the Mohawk-Hudson.

As the territory involved in this history has considerable north and south distance it is necessary to recognize the deformation or warping of the land which has taken place since the ice removal. It is certain that in the Ontario district a northward lifting of two or three feet per mile has occurred. In this paper the northward uplift is counted as two feet per mile, in correlation of altitudes, which corresponds to the figure used by Professor Woodworth for the Hudson district. The east and west deformation is so small that for the present it is neglected.

To save repetition the terms col, notch and pass are used as equivalents in this writing; and when a pass was occupied by a river it is termed outlet, channel, or escape.

BLACK VALLEY GLACIAL WATERS

PHYSIOGRAPHY

New York State, because of its peculiar physiography, probably surpasses any other district of equal area in the world in the number and excellence of its Pleistocene glacial lakes. Taking into account the several elements involved in the production and life of a glacial lake, the ice-dammed waters held in the basin of the Black river, in Jefferson and Lewis counties, affords one of the finest examples. The reasons for this excellence lie in the favorable attitude, direction, dimensions and relations of the valley; the simplicity and clearness of its history; the three distinct stages with different directions of overflow; the pronounced channels and deltas due to the outdrainage; and the remarkable development of sand plains built on the east wall of the valley by the indrainage from the Adirondacks.

The Genesee valley waters probably have no rival in the world in the number of distinct stages, nor in the number of far-separated great river systems to which the waters at different times were contributed; but the greater simplicity of the Black valley lake makes it a more typical and suitable example for study.

The district involved in this history is partially mapped in Sackett Harbor, Watertown, Carthage, Port Leyden, Boonville, Remsen and Oriskany sheets of the State topographic map. The map of the quadrangle north of the Port Leyden and east of the Carthage sheets is not yet available. The drainage of the area is shown in the sketch map, plate 1, while details are shown in plates 2–4.

The Black river carries the heavy drainage of a large area on the west slope of the Adirondack highland. The river has its source in the district of Ice Cove mountain, in the east edge of Herkimer county, North lake being an expansion of its headwaters. For something over 20 miles its course lies southwest, when it swings to northwest passing through Forestport and Hawkinsville. In this upper reach of about 30 miles the river has no pronounced valley, but some three miles past Hawkinsville, and three miles east of Boonville, it enters the head of the conspicuous and capacious valley which popularly bears its name. This valley extends northwest 40 miles to Carthage where it opens into the broad St Lawrence lowland. From Carthage the river curves around to the west and flowing through open country with only a shallow, postglacial channel, passes through the city of Watertown, and enters Lake Ontario at Dexter, near Sackett Harbor.

EDUCATION DEPARTMENT
JOHN M. CLARKE
STATE GEOLOGIST

UNIVERSITY OF THE STATE OF NEW YORK
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BULLETIN 160 PLATE I

KEY MAP

GLACIAL WATERS IN THE BLACK AND MOHAWK VALLEYS

H. L. FAIRCHILD

1909

The heavy lines show the divides, crossed by the outlets of glacial waters.

Scale 1/950400

0 5 10 15 30 45 Miles

A series of parallel streams from the Adirondacks joins the Black river on the east, two of which, the Moose and Beaver, are even larger than the Black river proper. Three factors produce this heavy drainage: the large area, the high altitude and the west-facing attitude, the two latter producing the condensation of moisture from the prevailing westerly winds. In glacial time the wind direction was probably similar to the present and we have every evidence that in this area the precipitation and drainage were very large.

The tributaries to the river from the west are short and weak, with the exception of the Deer river which joins a few miles above Carthage. The lack of western tributaries is due to the narrowness and steepness of the west wall of the basin and its lee position with reference to moisture-laden winds.

The prominent physiographic feature of the Black river basin is the Boonville-Carthage valley. Boonville is situated at the lowest col or pass between Black river waters and drainage to the Mohawk, through the Lansing kill, the altitude of the divide being about 1130 feet. (The summit level of the canal, in a rock cut, is 1120.) Carthage lies on the west side of the mouth of the valley, with altitude of 740 feet on the river bridge.

The west wall of the valley rises steeply in scarps and terraces of limestone until capped by shales at the height of 1800 to 1900 feet. The east wall, with irregular topography, rises slowly into the Adirondacks. The topographic contrast between the two sides of the valley is well shown in plate 3.

The mantle of drift on the west valley wall is scanty; but on the east slope the glacio-lacustrine deposit is remarkably heavy (see p. 15). Crystalline rocks underlie the east slope and the valley bottom and appear in places along the foot of the west slope, conspicuous from the railroad. Bosses of the crystallines project up through the alluvium of the valley, producing the peculiar topography indicated by the contouring on the Carthage sheet east and north of the city. These protruding masses, developed by atmospheric erosion in preglacial time and rubbed into smoothness by the ice abrasion and then half buried in stream and lake deposits, are conspicuous features at many points in the valley. Tens of thousands of huge blocks of the crystallines have been spread by the glacier over the country to the southward, especially along the moraine belt extending southeast from Boonville, as shown in plate 18.

Apparently this great north-sloping valley of the Black river was developed by millions of years of weathering and stream work

along the belt of contact between the old crystallines and the onlapping Ordovicic sediments; and during the development of the valley the axis of the valley has shifted westward against the outcrop of the sedimentaries.

OUTLINE OF THE LAKE HISTORY

This history is concerned with the waning and disappearance from the region of the latest or Wisconsin ice sheet, though it is quite probable that this history may be a duplication of that of earlier ice recessions. Some topographic features, like those in the Watertown district (the Rutland Hollow valley for example), may be the cumulative effect of multiple advances and recessions of the ice sheets.

The three broad elements in the history are: (1) the larger features of the land relief (described above), or the topographic control over the ice movement and the water flow; (2) the waning ice body on the north, acting as a receding dam and holding the imprisoned waters up to certain outlets of escape; (3) the impounded waters finding lower and lower escape in different directions, as shown by the outlet channels and the lake plains.

The glacial waters of the Black valley had four main stages, determined by four principal directions of escape. The first and highest stage was that of waters not limited to the Black valley but extending into the Mohawk area and controlled by outlets from the latter. The second stage had overflow to the southeast, through Remsen into the waters held in the Mohawk valley, the altitude of the channel heads being 1240 feet. The third outflow was at Boonville to the southwest, cutting the Lansing kill gorge, with ultimate escape to the Mohawk valley. The fourth and less simple stage was controlled by westward escape around the north end of the great ridge which separates the Black valley from the east end of the Ontario basin, comprising water levels from 1200 down to the Lake Iroquois plane, about 735 feet in the Carthage-Watertown district. The complete history must include the Iroquois waters, which flooded the lower end of the Black valley.

FIRST STAGE: MOHAWK WATERS; HERKIMER LAKE

There seems to have been a stage in the waning of the ice sheet when the Ontarian lobe, pushing east over the district of Oneida lake and Rome, thrust its front, with a northwest-southeast trend, against the foothills of the southwest flank of the Adirondacks.

View on Alder creek moraine

One and one-half miles southeast of Alder creek. Looking west. A characteristic scene.

The map, plate 2, shows this frontal moraine which was built along the ice margin, extending from Boonville southeast across the map.

While the ice was building this moraine the high-level waters which occupied a section of the Mohawk valley flooded the ground in front of the ice. The heavy drainage from the mountains brought down an enormous volume of detritus into the shallow waters fronting the glacier and built the extensive sand plains in the region of Forestport, having an altitude from 1440 feet down, and which apparently entirely filled the lake in that district. These delta deposits are described later (page 12).

This lake was held between the Ontarian and Hudsonian ice lobes and is believed to have outflowed through the Otisco and Unadilla valleys to Susquehanna drainage. It is described later in this paper (see page 19). The waters fell by the ice recession opening lower outlets in the Schenectady region, and the lowering was probably going on while the ice front in the Forestport-Remsen district was receding. At length the water surface fell below the divide or water-parting which bounds the Black river hydrographic area and the Black waters were differentiated as a distinct lake.

SECOND STAGE: FORESTPORT LAKE; REMSEN OUTLET

The first outflow of the distinctive Black waters was across the moraine, forming the divide, north of Remsen, and then south through the depression in which Remsen is located. The river reached standing waters and built deltas four miles south of Remsen, at Trenton and Trenton Falls. These features are shown in plate 2.

The Forestport lake with its overflow by Remsen must have persisted until the ice front had receded southwestward halfway to Rome, or to the west flanks of Quaker and South hills through a distance of over 10 miles, so as to open the Lansing kill outlet. The altitude of the lake surface was about 1240 feet during its closing phase. The altitude at the inception of the lake was as much above 1240 as was the amount of downcutting of the Remsen outlet, which was no more than perhaps 20 or 40 feet. It could not have been as much as 80 feet, as the next highest col, three miles northeast of Remsen with map altitude 1320 feet, is uncut by stream flow. We do not know where the early overflow and cutting occurred and we have no check in delta heights in the lake area, as these lie at various heights, this lake being merely the successor of the higher Mohawk waters.

The Forestport waters were shallow and the boundaries very

irregular. The abundant detritus brought into the shallow lake by the copious drainage from the southwestern Adirondacks, through the upper Black river and neighboring creeks, seems to have quite completely filled the lake, producing the broad delta plains described below.

The Remsen outlet heads in several indefinite passes among morainal knolls in the stretch four or five miles north from Remsen. By the topographic map the present altitude of these swamp cols is 1240 feet. About one mile north of Remsen the winding swampy channels unite into a single definite rock channel which continues for three miles south of Remsen and ends in terraces and scourways on the delta north of Trenton and Trenton Falls villages. The head of the rock channel north of Remsen is 1200 feet altitude. In the south edge of the village it rapidly falls to 1100 feet and in another mile it drops to 1000 feet. The fall of 200 feet in two miles gave the Remsen river a torrential character, the evidences of which are seen in the eroded limestones with abandoned cascades. These features may be well seen on the east and west road somewhat over a mile south of the village.

The flow of the distributaries over the delta northeast of Trenton and north of Trenton Falls is conspicuously shown by terraces and channels. These benchings, found specially on the slopes facing north and west, indicate that the receiving waters occupying the Mohawk valley were slowly falling during the life of the river. It also appears that the Remsen river ceased its flow while the Mohawk water was standing with an altitude of about 980 feet, the height of the lowest well-developed plains.

Forestport sand plains. The delta plains built in the Forestport and higher lakes by the tributary drainage are very extensive, covering nearly all the area for several miles north, east and southeast of the village, and must have quite filled the shallow waters. Superficially they are mostly sand and were derived from the wastage of the quartzose rocks of the Adirondack crystallines. These sand deposits were laid down over the ice-laid or moraine deposits, which in places project up through the lake beds. This is strikingly illustrated in the lofty kame hills, the most conspicuous heights of the district. The village of Forestport lies on the west side of a large kame hill. Another mass lies one and one-half miles south of the village, and a very prominent pair of steep sand hills about three miles northeast, locally called Dustin hills, rise 140 feet above the broad expanse of level sands. The ice block kettles which are such

Stony content of the till

Excavation one mile northwest of Alder creek. Looking southeast. The rejected material shows the stony character of the ice-laid drift in the Alder creek moraine.

a prominent feature of the Port Leyden quadrangle (see page 15) are wanting in the Forestport sand plains.

These sand plains seem to have been built against or near the ice margin, and the materials are theoretically of triple origin: largely detritus brought in by the Adirondack drainage; partly contributed by streams pouring out of the melting glacier; and partly derived from the wave erosion of the kames and glacial deposits.

The Forestport sand plains lie in a series of sloping terraces, declining westward. Five miles northeast of Forestport, on the north edge of the Remsen sheet, the highest plain is 1400 feet, though there are evidences of wavework still higher. Other terraces or benches of the district are found at all levels down to 1140, the terrace on which the village stands. Near Enos, six miles southeast of Forestport, are sand plains at 1420 down to 1360 feet. The levels above 1300 feet must certainly belong to the first stage, or Mohawk waters, while those below 1200 feet as certainly belong to the next and lower stage, Port Leyden lake. It will not be possible to correlate all the terraces with definite attitudes of the waters, and the tilting of the land complicates the study. But this fact is brought out clearly, that the sand plains were spread out in slowly subsiding waters and were extended westward at lower and lower levels as the ice front receded.

On the map (plate 2) the delta plains credited to the several lake stages are indicated by different shadings ("conventions") and the limits can not be exact. The altitudes of the upper and lower limits of the Forestport lake deposits are taken as about 1280 and 1200 feet. As a rule the shadings are restricted to terrace limits, but it is possible that some higher portions of sand plains marked as Forestport may belong to the earlier Herkimer lake, or that some of the lower parts may be deposits of the subsequent Port Leyden waters. However, in a general way the map must indicate the true relations.

These plains have been noted by W. J. Miller (see title 27, pages 42–45).

In the maps showing the waning of the ice sheet the Forestport lake is not indicated, but it belongs to a phase between those of plates 13 and 14.

THIRD STAGE: PORT LEYDEN LAKE; BOONVILLE OUTLET

This lake is the one of longest duration in the life of the Black valley glacial waters. Its outlet was the narrow, deep gorge of the present Lansing kill, extending from Boonville south some 10 miles

to the Mohawk river at Northwestern. The history of the lake is graphically indicated in plates 15 and 16 and the central part of the basin is shown in plate 3. The lake was narrow at the south end, being about two miles wide at Port Leyden, three miles at Lyons Falls, five miles at Glenfield and expanding northward. The west shore of the lake was quite direct, lying along the limestone slope, but the east shore was very irregular, being formed by the enlarging deltas built by the Adirondack drainage. The depth of the lake was about 260 feet at Port Leyden, 300 feet at Lyons Falls and 400 feet at Glenfield.

The outlet valley is a narrow, deep channel in shale, evidently cut by a vigorous stream of relatively short life, and well shown in plate 2. It does not appear just where the initial overflow began, but we know that it could not have been higher than 1240 feet, the altitude of the deserted Remsen outlet. Before the Lansing kill valley became the outlet of Black waters it must have been flooded by the Forestport lake, until the ice front receded from the Steuben valley between Trenton and Northwestern (see page 35). The ultimate head of the glacial river and the present col is a flat stretch extending southeastward from Boonville about two miles and now occupied by the summit level of the Black river canal. This has one lock (no. 71) in Boonville and the next (no. 70) over two miles south, the water surface being 1120 feet. About one and one-half miles south of the village the canal has a cut of 10 feet in limestone, which makes the present altitude of the outlet channel about 1130 feet. Immediately below the head of the channel the river had cascades, the widened main channel having narrow and steep trenches on both sides, with a plunge basin and lakelet on the east side.

One mile below the cascades the channel becomes very narrow, in shale, with only room for the present creek, the highway and the canal, and so continues for six miles. The succeeding five miles to Northwestern have a somewhat wider but yet narrow valley, and from that village the valley is open, preglacial, and partly filled with detritus. Below the village of Delta the ancient valley was blocked with moraine and the present Mohawk has been compelled to cut a channel on the east side of the old valley, locally known as the "Palisades." Delta village lies on the old lake bottom and present Mohawk flood plain.

From the channel head two miles below Boonville, to Northwestern, a distance of about 11 miles, the channel bottom drops 530 feet (from 1130 to 600), the canal having in that stretch 48 locks.

Sandplains in Black valley

A view of the bold front of the plain, as seen looking east across the Black valley from a point two miles east of Talcottville.

Kettle in Delta plain

Four miles northeast of Lyons Falls. Looking northwest from road. A small sample of the numerous basins in the sand plains.

The deltas built by the Boonville river in the falling Mohawk lakes will be discussed later (see pages 35).

The sharp hills about Boonville are kame-moraine and similar to those previously noted in the Forestport district. Sperry hill northeast of the village rises 280 feet over the village, or to 1400 feet. At present the canal is chiefly used for carrying sand from these hills to Utica and eastward cities.

Sand plains in Port Leyden lake. The east shore of this lake received an enormous supply of detritus. The deltas are developed on a magnificent scale and form a practically continuous sand plain along the east side of the valley, as shown in plates 3, 20 and 21. The plain is trenched by the Black river tributaries and broken by numerous deep, irregular basins or kettles produced by the melting of blocks of ice which had become detached from the waning glacier and surrounded, or sometimes wholly buried, by the delta sands. These ice block kettles probably surpass in size, number and excellent character any other district in the State.[1] (See plate 21.)

Some of the higher sand areas along the east edge of the Port Leyden quadrangle and eastward may perhaps have genetic relationship to local waters held along the ice margin, or possibly even held between the Black valley ice lobe and alpine glaciers from the Adirondacks, but the broad, smooth plains indicated on the map must certainly correlate with the Boonville outlet. About Bucks Corners the sand plain abuts against moraine at 1220 feet. Northeast of Port Leyden the good delta plain is 1215 to 1220; south of Brantingham it is up to 1225 to 1230 feet. Above these levels the plain becomes duny, rolling and irregular. Beyond the upper limits of the plains dune knolls are common. The northward rise of the sand plains on the Port Leyden sheet averages about five feet per mile, and as they are thought to have been deposited at about the same time this slope may be taken as the amount of the deformation.

The depth of the lake deposits must be great, as the kettles, except a few at the north edge of the map, do not hold water, though some of them are over 60 feet deep; and rock or till rarely appear except in the deeper stream cuttings. Some of the kettles show cobbly kame gravels and boulders on their walls.

The sand plains are now destitute of forest and occupied by grass and scrubby growth of scattering trees.

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[1]A good example of a large kettle in a small delta in central New York is described in Jour. Geol. 6:589.

FOURTH STAGE: GLENFIELD LAKE; COPENHAGEN-CHAMPION OUTLETS

The remarkable series of west-leading channels shown in plate 4 are the outlets of this water.

This lake did not have a permanent level but a series of falling levels as new outlets were opened on the north-facing slopes southwest of Carthage. The primitive and highest level was something over 1200 feet, the present altitude of the bottom of the highest channel, a mile northwest of Copenhagen. The lowest level was a blending into the waters of Lake Iroquois at about 740 feet. The lowest scourways seem to lie through West Carthage, a well-defined channel west of the village being 760 feet.

At the beginning of this stage the waters extended up the valley to Boonville, but the area diminished as the surface fell by the opening of successively lower outlets until only the lower or northern part of the valley was flooded, probably only the stretch from Carthage to Glenfield. This stage is called the Glenfield, as that village is the most northerly in the axis of the valley.

The northern part of the eastern shore of the lake is on territory not yet mapped, being the quadrangle east of the Carthage and north of the Port Leyden (Lowville sheet).

The curving course of the outlet channels shows how the ice front curved about the higher ground and deployed on the low ground, thus forcing the drainage against the convex slope. The earliest flow must have passed along the ice front east of Adams and finally reached the primitive Iroquois waters farther south, perhaps at Sand Bank or Williamstown, or possibly as far as Camden. All the subsequent drainage found its base level in Lake Iroquois at Adams, where an extensive delta was built, with altitude 620 to 630 feet and fronted by the Iroquois beach. The higher channels were cut in Lorraine shales, the lower in limestones.

When the ice front lay higher on the land slope there must have been a similar drainage past the ice margin of the local waters and such channels of the earlier time are indicated on the map, east and southeast of Adams, in the towns of Rodman and Lorraine, lying along the general slope with a southward direction. This local drainage probably ultimately reached the early Iroquois farther south; but the local drainage of a still earlier time must have followed along the ice margin until it reached the Mohawk waters in the vicinity of Rome (see page 34). No attempt is here made to fully map the high-level ice-border drainage, it being represented on plate 4 only where casually found. However, the cross-ridge

Glacial stream channel

One mile north of Champion and four miles west of Carthage. Looking south, upstream.

channels, from valley to valley, and parallel with the general land slope, must occur over the west-facing and south-facing slope of the high ground as far as to the Rome district.

Deltas in Glenfield lake. During the previous stage a small lake had been held in the valley of Deer river, along the summit of the great ridge between the Black and Ontario valleys. The escape of the Deer lake must have been westward through a summit swamp, north of New Boston at about 1530 feet, into the ice-border drainage noted above. One channel seems to lie through Barnes Corners. When the ice barrier receded to the vicinity of Harrisburg the Deer lake escaped eastward and so continued by a series of small but distinct channels at falling levels until the Deer lake was drained. These outlets of Deer lake built a delta of conspicuous size on the west shore of the Black waters near Harrisburg, and five miles northwest of Lowville. Other deltas occur where the Deer river dropped its detritus in the falling Glenfield lake below High Falls and at Kings Falls. The reader should observe that the Deer lake outlets are the only east-leading channels on plate 4.

FIFTH STAGE: LAKE IROQUOIS

When the ice front receded from the promontory lying between Watertown and Carthage the distinctive Black valley waters ceased to exist and the Carthage district was occupied by the waters of the great Lake Iroquois. The Iroquois beaches are found in conspicuous form on the steep slope northeast of Watertown, at 733 feet. Eastward toward Champion Huddle and Carthage the shore line features are fragmentary, but the altitude is taken as 740 to 750 feet. The plain of the Black river above Carthage is now 730 to 740 feet, and the Iroquois waters at first probably extended some miles up the valley, but soon filled with the river silt, becoming a swamp. The real delta of the Black river in Lake Iroquois is the very extensive sand plain heading northwest of Carthage forming the "Pine Plains," which extend to Black River, Felts Mills and Leraysville. The head of the plain is about 735 feet, declining to 520 at Leraysville.

Until the quadrangle north of Carthage is mapped the Iroquois features of the region can not be satisfactorily described.

PREWISCONSIN TOPOGRAPHY

The tract of country covered by the heavy channels in plate 4 exhibits many scarps, terraces and hollows which antedated the river flow under discussion. Some of these are comparable to the

scarps and benches shown in plate 3 on the west side of the Black valley. These features may be certainly attributed in part to the millions of years of weathering and stream work before there was any ice invasion. But the peculiar shaping was done in part by the eroding action of the ice sheets, and specially by the forced glacial drainage of ice sheets previous to the Wisconsin.

A good example of these anomalous features is the Rutland hollow and hill east of Watertown. Here is a capacious valley behind an isolated rock mass, both having northeast by southwest direction, transverse to the general land slope and normal drainage but consonant with the ice blockade and ice-border drainage. It seems quite certain that any earlier ice invasion must have produced, both in advance and retreat, lakes and drainage somewhat similar to those here described. The accumulating evidence of more than one glacial epoch in New York adds force to the thought that some of the peculiar relief features of the region have been produced by multiplicity of glaciation and glacial drainage. The lowland of St Lawrence valley and east of Lake Ontario exhibits many anomalous features which harmonize with this view.

Stream deposits in Lake Iroquois

East Watertown, mouth of Rutland hollow. Looking southeast. At the left is seen a mass of bouldery till enclosed in the sand beds.

MOHAWK VALLEY GLACIAL WATERS

FIRST STAGE: EARLY ADIRONDACK DRAINAGE

In describing the outflow of the Black valley waters reference was made (page 12) to deltas built at Trenton by the Remsen river and north of Rome by the upper Mohawk. These deltas are too massive to represent local and transient lakes held in embayments along the edge of the glacier, and their position and relation to the ice front and to the open valley forbid the assumption. The ice front here was a lobe pushing in from the west. The deltas lie on the north border of the broad Mohawk valley and were evidently deposited in broad waters which flooded the Mohawk and extended far east. The existence of other high-level lake deposits in the Mohawk valley has long been known, terraces and level stretches being conspicuous at intervals from Utica to Schenectady. The waters were ice-dammed. The Hudson valley ice lobe blocked the valley on the east while the Ontario ice lobe blocked it on the west. With the knowledge already gained concerning the positions of the receding ice fronts, the impounded waters and the inclosing topography, the conclusion is imperative not only that the Mohawk valley held glacial waters but that they were sustained at different levels.

In the waning and thinning of the ice sheet which overspread central and northern New York there must have been a stage when only a neck or strait of ice rested in the Mohawk valley, connecting the Hudsonian and Ontarian lobes of the Laurentian glacier. The earliest glacial waters of the Adirondack region must have gathered in the valleys along the southern slopes of the highlands and resting against the margin of the ice in the Mohawk valley. The only escape for these waters was southward across the Mohawk ice at its lowest point (see discussion of this matter in the introduction). The sand plains in the Adirondacks at high levels probably belong to this time. Some of the water deposits were probably accumulated in restricted waters, held by local glaciers or by tongues of the receding ice sheet which surrounded the exposed highlands; but the ultimate escape of the waters must have been to the south and over the belt of stagnant ice which lay in the Utica-Little Falls section of the valley.

The early removal of the ice sheet from the Adirondack highlands and the consequent existence of high-level glacial waters in the mountain district has been recognized by F. B. Taylor (see title 36). He noted terraces and sand plains in the Saranac valley at 1370

feet, and other water planes at 1400 to 1600 feet. For these waters he proposed the name Lake Adirondack.

As these waters must have been extremely disconnected, lying at different levels about the margin of the exposed highlands, and tributary to those on the south side with ultimate escape across the ice strait in the Mohawk valley, the writer hesitates to call them by a name implying a distinct lake. However, the name Adirondack waters holds both by priority and appropriateness.

The existence of standing waters in the larger Adirondack valleys has also been recognized by I. H. Ogilvie (see title 29), but no altitudes are given.

It is not possible now to locate with absolute confidence the point or points of outflow, or the valley south of the divide which carried southward the glacial waters. It was not necessarily by the stream which today has the lowest col on the divide between Mohawk and Susquehanna drainage, and there might have been more than one point of escape.

The col at Cassville and Richfield Junction (Delaware, Lackawanna & Western Railroad) 10 miles south of Utica, has a combination of characters that are suggestive in this connection (see plate 5). Here is a smoothed col, over a mile wide, heading at about 1260 feet the wide, smooth valley at North Bridgewater now drained by the west branch of the Unadilla river. A broad sand plain north of the railroad junction has the altitude of the col and indicates standing water north of the divide. A kame-moraine area north and west suggest a long stand of the ice margin at this place with heavy outwash. This pass could not have been the outlet of widespread or open Mohawk waters as the Cedarville pass, six miles southeast, is 40 feet lower. The writer has supposed (see title 17, page 20) that the glacial waters of the Sauquoit valley were responsible for the characters of this pass, but they hardly seem competent. The pass at Bouckville, the head of the Oriskany valley at 1150, is also suggestive, but it lies far west. Another pass which certainly carried a flood of water is the col at the head of the Otsego-Susquehanna valley with altitude 1360 (described page 23). If this outlet did not carry the earliest flow from the Adirondacks across the ice strait it certainly did carry glacial waters before the Cedarville pass was opened. It has also the location opposite what would seem to have been the weakest section of the waning ice strait.

The ice in the valley may have been so heavily burdened with rock rubbish that submergence could not lift it, but the waters must have

aided the melting, and eventually a section of the valley was free of ice and held only the earliest of the Mohawk glacial lakes.

We have some facts which bear on the matter of the location of the weakest section of the Mohawk ice strait. The existence of drumlinlike forms on the south side of the valley and with east and west direction has been recognized since the publication of the Utica and Richfield Springs sheets. In 1908 Professor Brigham described west-pointing drumlins in the Johnstown region (see title 6, page 25). In the autumn of the same year the writer determined that drumlins indicating a westward flow of ice exist in perfect form in the district northeast and northwest of Richfield Springs, but that they terminate east of the Utica meridian. The ice-molded drift forms a restricted area, mostly on and south of the line of divide, about eight miles wide beginning north of Otsego lake and stretching northwest to beyond Cedarville, a distance of about 18 miles. The drumlins are partially indicated on plate 5.

It has been shown that drumlins are a product of the sliding movement of the thinning ice edge when under efficient thrustal motion of thick ice in the rear.[1] The Richfield Springs drumlins were produced by the movement of the thinner ice on the high ground, under the push of the thicker ice in the valley eastward. The more remote pressure was, of course, from the Hudson valley lobe. The drumlin-forming ice was an overflow from the valley ice tongue.

Here we have evidence of ice flow up the valley, from the Hudsonian lobe; and we have proof that for a long time subsequent the Ontarian lobe lay over the Rome district. The westward flow of the Mohawk valley ice was, at this phase, probably met by the opposing Ontarian ice somewhere in the Little Falls-Utica district. The locality of the meeting between the two ice tongues, in the later phase, would probably be the place of subsequent separation.

The question is now pertinent: Why did the Hudson ice push so far westward up the Mohawk valley, meeting the Ontario glacier much more than half way, while at a later time the Ontarian lobe lingered over Rome, at the west end of the valley, when the Hudson valley in the Schenectady district was clear of ice? The explanation seems to lie in the form and the relative altitude and cross section of the St Lawrence and the Champlain-Hudson valleys. When the ice body was thick over both the Champlain-Hudson and the St

[1] Drumlins of Central Western New York. N. Y. State Mus. Bul. 111, p. 429.

Lawrence-Ontario the former dominated in the Mohawk region, for the reason that the course was more direct and the distance less. But as the ice body thinned this advantage was overbalanced by the narrower and more restricted cross section of the Champlain valley as compared with the open, though somewhat higher St Lawrence.

At the time of the ice retreat the north boundary of the State was depressed at least 600 feet below its present altitude and the entire Mohawk area was lower than now and probably somewhat lower relatively to central New York.

SECOND STAGE: HERKIMER LAKE

The sketch map, plate 1, shows the southern limits of the Mohawk drainage, including the Schoharie valley. The passes across the divide which bear evidence of stream flow are also indicated.

The first step in the study of the glacial lake history is to determine the altitudes of the water planes and to find the points of overflow or the correlating outlets, keeping in mind the fact of some later northward uplift. It was discovered that very extensive sand plains north and east of Forestport and near the hamlets of Grant, Gray and Ohio, in the basins of the upper Black river and of West Canada creek, had an elevation of 1440 feet, while other extensive plains ranged in the neighborhood of 1300 feet. Examination of the passes leading out of the Mohawk basin shows a strong river-cut channel in limestone at the head of the Otsego valley and seven miles east of Richfield Springs, with an altitude of about 1360 feet. Another capacious channel of perfect form lies at Cedarville, eight miles northwest of Richfield Springs, at the head of the Unadilla-Susquehanna, with an elevation of 1220 feet. Farther west is only one pass with lower altitude than the Cedarville, at Bouckville, four miles north of Hamilton, leading to the Chenango river, with an elevation of 1150 feet. Passes at Richfield Junction and at Sangerfield have elevations of 1260 and 1240 feet. All these features are shown on the Richfield Springs, Winfield, Sangerfield and Morrisville sheets, and the two passes first named are shown on plate 5. The passes on the east can have no relation to the Ohio water planes, being either too high or too low, with the exception of one four miles south of Middleburg in the Schoharie valley, at the head of the Catskill creek, with elevation 1200 feet. Examination of this col shows a tiny stream cutting across the summit but incapable of carrying a respectable creek; and the flow there was probably northward.

Taking the several elements of the problem into consideration the only pass leading out of the Mohawk basin which correlates with the widespread sand plains having an altitude of 1400 feet and upwards is the one at the head of the Otsego valley, between Springfield Center and Summit lake. A northward uplift of about two feet per mile brings this channel, 1360 feet, into close accord with the high sand plains at Forestport, Grant, Gray, Ohio and Devereaux-Stratford.

The Summit lake channel is in limestone. The map makes the divide a mile north of the lake but the cut channel is at and south of the lake. Going north from Springfield Center singular heaps and knolls of limestone rubbish are seen, which are clearly piled by plunging or cascading waters. Beyond these the channel is bare limestone in ridges and hollows with lateral recesses and terraces. North of the lake and swamp are moraine knolls at the head of the pass, at about the altitude of the lake. The aneroid and hand level made the stream-cut limestone ridges south of the lake somewhat higher than the lake. It would seem that the original rock divide must have been in the limestone south of the lake.

The morainal surface at the head of the pass and the irregular bed in the eroded limestone indicate that the river did not have length of life sufficient to level or smooth the channel entirely across the col. The head of the pass may have been ice-obstructed; and it is possible that the flow in this pass was directly from across the strait of ice which filled the valley on the north. This seems the probable locality where the early ice-bound waters, held about the exposed foothills of the Adirondacks, would find ultimate escape.

No clear separation can now be made between the Adirondack waters which were drained across the ice and the early lake in the ice-free section of the valley. As most of the features described in this chapter lie in the area of Herkimer county the name Herkimer lake may be properly given to the waters, without close discrimination as to altitude and outflow.[1]

The Summit lake channel correlates with the 1400–1440 feet sand plains, the difference of 80 feet giving the theoretical uplift of two feet per mile, with some allowance for depth of the river and downcutting of the outlet. In the same way the Cedarville channel, 1220

[1] The sand plains at Forestport are in Oneida county; part of those at Devereaux-Stratford are in Fulton county; and the Summit lake outlet is just over the line in Otsego county. The Cedarville channel, which was the outlet of the positively open-valley water, is in Herkimer county.

feet, correlates with the sand plains at or near 1300 feet. The latter are well developed contiguous to the higher plains, and represent the lower level of the Herkimer lake.

With the opening of the Cedarville channel the Herkimer waters fell about 100 feet. The amount of downcutting is not evident, but the present channel is 140 feet lower than the Summit lake channel.

The Cedarville channel was located theoretically in advance, simply from the map.[1] Its excellent character even surpassed expectation. It is a handsome and typical river channel of mature form. It is at least one-fourth of a mile wide; steep banks, uniform width and grade, with the long stretch of level summit occupied by a swamp of cedar which has given name to the village. The valley below the col, through East Winfield, West Winfield and Unadilla Forks, has the characters produced by a strong river with low gradient.

It is possible that the Ontarian ice lobe backed away along the southern divide sufficiently to allow the Herkimer waters to find escape by the Bouckville pass, at 1150 feet, but it is not probable. A high ridge between the Unadilla and Sangerfield rivers extends north nearly to the parallel of Clinton, ending in Crow hill, six miles southwest of Utica. The ice lobe in the Utica district probably pressed against this salient to the close of Herkimer time.[2]

The Cedarville channel is believed to have been the final outlet of the Herkimer lake, and to have persisted all the time required for the ice lobe in the Hudson valley to recede sufficiently to open a lower pass in Albany county, initiating the next stage.

The extent of the Herkimer sand plains is suggested by plates 2 and 7, where they are shown ranging from 1440 down to 1280 feet. They will be found in many districts, either where heavy streams poured into the lake or where there was outwash from the glaciers. The differential uplift must be taken into account, which may not be uniform far to the north. They should be found in large development through the Adirondacks, but will not occur in strength on

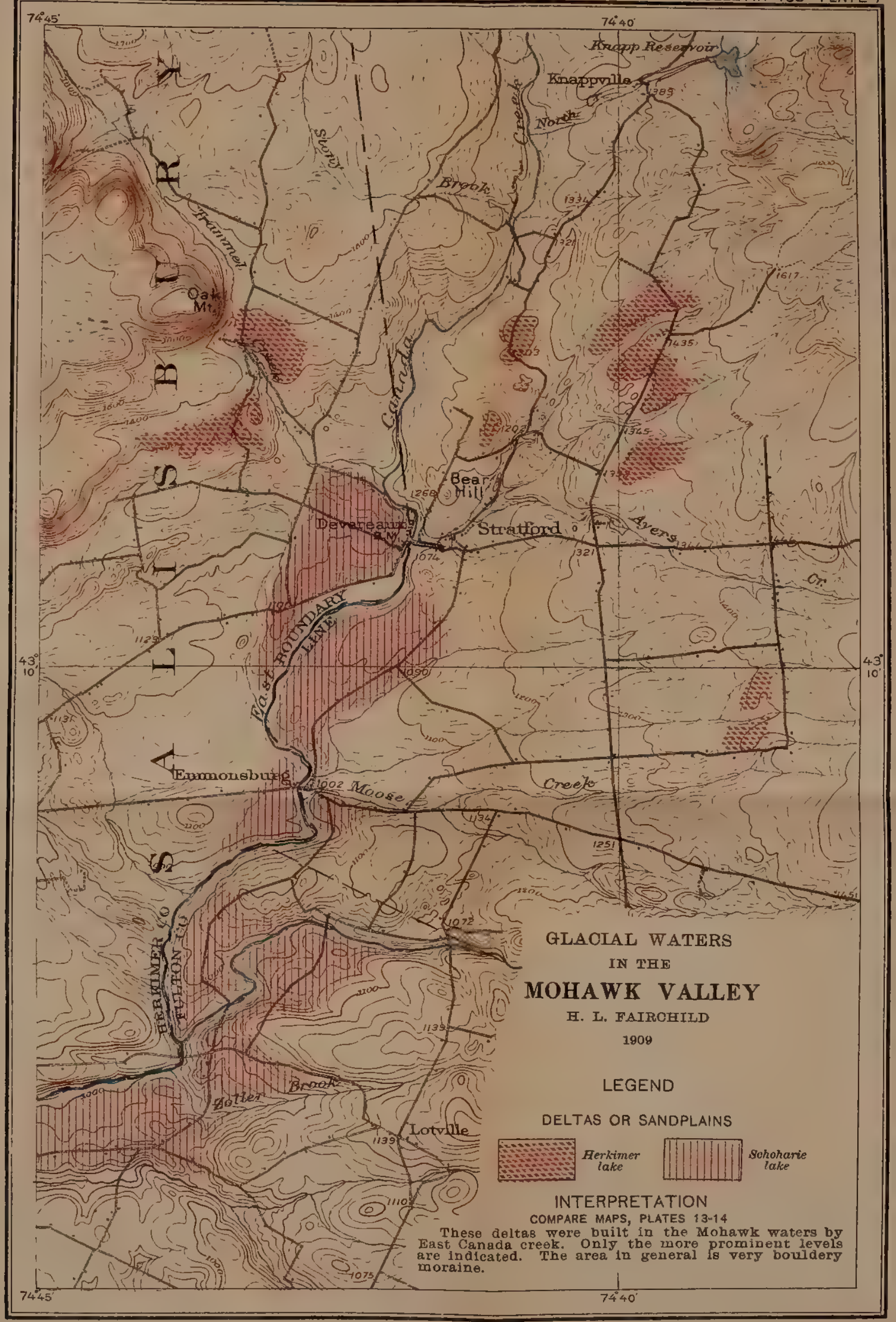
[1] The certain proof of the correctness of the glacial lake philosophy is found in the fact that nearly all the more important glacial stream channels in the State, described by the writer, have been located in advance of any visit, by the study of the topography in relation to the position of the ice front.

[2] The writer has described certain west-leading channels at Crow hill (see title 17, page 22), but they are regarded as having carried only the small volume of water from the Sauquoit valley on the east over into the Oriskany valley and Bouckville escape.

EDUCATION DEPARTMENT
JOHN M. CLARKE
STATE GEOLOGIST

UNIVERSITY OF THE STATE OF NEW YORK
STATE MUSEUM

BULLETIN 160 PLATE 7



GLACIAL WATERS IN THE MOHAWK VALLEY

H. L. FAIRCHILD

1909

LEGEND

DELTAS OR SANDPLAINS

Herkimer lake

Schoharie lake

INTERPRETATION

COMPARE MAPS, PLATES 13-14

These deltas were built in the Mohawk waters by East Canada creek. Only the more prominent levels are indicated. The area in general is very bouldery moraine.

Scale 1/62500

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.

Datum is mean sea level.

the south side of the Mohawk valley as the streams there are relatively short and weak, the slope steep and the strata chiefly shale.

Toward the close of the stage the Herkimer waters probably extended from Utica to Johnstown. Its precise limits are unknown. Plate 13 gives suggestion of an early phase.

The evidences of standing water at high levels throughout the Mohawk basin are abundant and conclusive. Above about 1200 feet the features are chiefly the extensive sand plains by the northern drainage, but below that level the proofs are more varied and very common. Delta plains usually occur, at falling levels, along the stronger streams and in hundreds of localities where the detritus was not so abundant as to produce definite and conspicuous plains we find silted hollows and sandy stretches.

Below about 1200 feet the valley walls exhibit the peculiar smoothness or softness of outline characteristic of wave-washed slopes. Distinct beach lines are not uncommon and in some localities the horizontal marking of the slopes due to wave erosion are striking. They are specially conspicuous in the Little Falls district where the soft Utica shale of the valley walls combine with other factors to favor their production. Some of these beach lines require for visibility a viewpoint of proper altitude and a suitable lighting.

The best example noted by the writer of the high-level beach lines lies on the south side of the valley four miles southwest of Little Falls, and may be clearly seen from the New York Central and the electric railroads in all lights, but are specially prominent with a sunset lighting. They are shown in the accompanying figure and in plate 25.

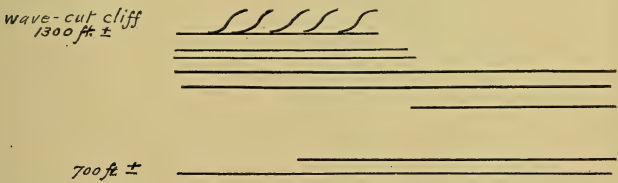


Figure 1 Sketch of beach lines produced by high-level waters in Mohawk valley, four miles southwest of Little Falls. View from river bank two miles southwest of village. Compare plate 25.

In a former paper these horizontal lines were attributed to stream work of ice-border drainage, but it is now found that they are the product of lake waters. The highest wave-work that is evident on the ground is at about 1300 feet, a cliff and terrace at the foot of

the summit knoll which was the site of the triangulation station (1372 feet). A farm house stands on the terrace by the highway which traverses the wave-cut hillside. The highest beach line of the series, shown in plate 25, is at about 1200 feet, and the lowest is at about 700 feet.

Similar conspicuous beach lines occur on the north side of the large valley, and also on both sides of the lateral valley leading southeast toward Newville. It would seem that the northwest winds were able here to produce wave and current work that was effective in carving the soft shales. Other examples of wave action occur east of Little Falls but require for clearness a higher viewpoint than the railroads.

Conspicuous shore lines lie on Sperry and Park hills east of Boonville, in the neighborhood of 1200 feet.

With recognition of their nature these beach lines will be found in many localities throughout the areas of the Herkimer and the lower lakes.

THIRD STAGE: SCHOHARIE LAKE

The only large valley opening into the Mohawk from the south is the Schoharie. The river rises in the heart of the high Catskills, the three headwater cols having, by the map, 1920 feet altitude. A glance at the map, plate 1, will show how the attitude of the valley, declining northward toward the receding ice barrier, fulfilled the primary condition for a glacial lake. The valley must have held glacial waters at different levels. Some of the passes at the head of the valley might have been blocked by local or alpine glaciers during the earliest phase, but one or more of them must have been the outlet for the primitive lake. Later the narrow gorge across the west divide at 1560 feet must have become effective. From the map it would appear that the next successive outlet would be the 1200 feet pass on the east divide, four miles southeast of Middleburg, at the head of the Catskill creek. However, that does not seem to have been the order of events. The Middleburg pass never carried a large stream, and the small flow which did occur was probably northward into the Schoharie waters. This somewhat surprising fact is explained by two factors in the problem, first the postglacial deformation, and second, the larger topographic relation of the valley to the Hudson and Mohawk valleys. The Middleburg col is 25 miles south of the parallel of the Cedarville channel. If the northward uptilting of the land involved the Schoharie valley, the two feet per mile of tilt would make the Cedarville pass 30 feet

Cobble heaps on Delta tract

One mile southwest of Delta. Looking south from highway. Note the subuniform size and rounded forms. A characteristic view on the delta plains.

Beach lines in Mohawk valley

Wave-work of lake waters, south side of Mohawk valley, four miles southwest of Little Falls. Mohawk river in foreground.

below the Middleburg, while half that slope would still keep the Middleburg plane superior. The second factor involves the ice barrier. During the earlier phases of the Schoharie lake history, when the Middleburg pass might otherwise have been effective, the Hudson valley ice tongue probably lay against the Catskill highland, west of Catskill village, at so high a level as to block outflow of the Schoharie-Mohawk waters by the Catskill valley. Later, when the ice was removed from the Catskill scarp the Cedarville outlet was probably open at an inferior level. Detailed study of the deltas built in the Schoharie valley by side streams will probably show a strong lake plane somewhat beneath the Middleburg pass, the latest phase of the Herkimer lake.

Professor Brigham has noted lake deposits in the Schoharie valley above Esperance and in the tributary Cobleskill valley, which he attributed to a morainal dam near Burtonsville, and he called the waters the Schoharie lake. The present writing would make the name include all the glacial waters which, extending through both the Schoharie and Mohawk valleys, had their escape across the east divide of the Schoharie basin. Local names may be desirable for any distinct phases of these waters.

Schoharie lake outlets. The first downdraining of the Herkimer lake and the initiation of the Schoharie came when the Hudsonian ice lobe, lying against the Helderberg scarp west of Albany, weakened so as to permit outflow across the east divide of the Schoharie valley.

The earliest outflow of the Schoharie waters was probably along the face of the Helderberg scarp, crowded between it and the glacier. Plate 6 indicates the channels along the face of Countryman hill and southward, specially under 1100 feet. The writer has not made close study of the district but sufficient to show that the saliences of the great scarp west of New Salem up to about 1200 feet have been scraped by powerful water currents. The map shows the southward continuation of these rivers, alongside the glacier, and parallel to the wall of the Hudson valley. Apart from any ponding of waters in the Mohawk basin such ice-border drainage was a positive necessity; but with the contribution of the Adirondack-Mohawk drainage added to the copious waters from the glacier melting there was a heavy concentration of flow along the margin of the ice tongue, seeking southward escape. The continuation of these channels far to the south is apparent on the topographic sheets.

It must not be thought that the Wisconsin glacial drainage is entirely responsible for these channels (transverse to the normal

direction of the land drainage of the valley wall). They were made by stream-flow and ice-wear of probably more than one earlier glacial epoch, and certainly were occupied by the lateral drainage during the advance of the last ice as well as during its recession. The glacial rivers which we are considering only finished a work partly done long before.

The ice body in the Hudson valley lying over Albany and Schenectady must have pressed against the Helderberg scarp for a long period. The hypothetical relation of the ice lobe to the land configuration is suggested in the maps, plates 14, 15.

There are two passes across the divide, in Albany county, between the Schoharie and Hudson valleys which are inferior in altitude to the Cedarville outlet, but only the lower one was effective as a river channel. The col at Knox, five miles southwest of Altamont, at 1160 feet, is uncut and no evidences of stream work are found on the slopes of the valley. It appears that during the earlier and higher outflow of the Schoharie waters along the face of the Helderberg scarp the Knox and Delanson passes were submerged in the lake waters. Eventually the lake was lowered so that flow occurred through the Delanson pass; and when the Schoharie waters were finally drained down to about 900 feet the Delanson river was established. The present altitude of the channel, two miles west of Delanson, is 840 feet.

This channel is a good example of an abandoned stream bed, though not nearly so capacious and mature as the Cedarville. The outflow was reduced in volume because the ice was out of the Mohawk basin and the supply of water from the melting glacier was greatly diminished. The life of the river may not have been long, as a still lower escape was to be opened northwest of Schenectady. The earliest flow through the Delanson channel was forced southeast through the valley of the Boxen kill and the site of Altamont.

The area of the Schoharie waters was probably the whole basin of the Mohawk and its tributaries east of Utica and all of the Sacandaga valley that was free of ice. The height of the water on the Little Falls parallel began at about 1200 feet and fell to about 880 feet. On the parallel of Schoharie and Cobleskill the water-planes will range from 1150 down to 830 feet (see plate 14).

No exhaustive study has been made of the planes and deltas of this stage, but sand plains have been noted in far-separated localities, some of which are indicated in plates 2, 7 and 8. The following delta plains are regarded as correlating with the Knox-Delanson

outflow: the upper plains at Prospect and Trenton Falls (1160–980); the lower at Devereaux-Stratford (1160–1000); the higher at Northville-Edinburg (1040–940); the lower at Poland (940–820); and the terraces in the Lansing kill valley and the upper Mohawk at 1200 to 920 feet.

It will not be possible to discriminate sharply the upper and lower limits of the Schoharie waters, as the Herkimer waters fell slowly to the Schoharie and the latter to the next stage. If either of the changes had occurred suddenly and through a large vertical interval the two stages would be distinct in their deposits. However, within the extreme vertical limits as given above there is a large range of levels which must certainly correlate with the Schoharie stage.

The evidences of standing water will not be emphatic on the south side of the Mohawk valley as the steep, short slope, the shale rocks, and the weak streams are unfavorable to production and to preservation of delta deposits.

FOURTH STAGE: AMSTERDAM LAKE

The outlet channels of this stage are shown in plate 6, and the hypothetical position of the ice front in plate 15.

During the preceding stage, the Schoharie, the ice must have thrust itself against the high ground west of Schenectady, the Rotterdam salient, so as to block the direct outflow of the Mohawk valley waters by the present Mohawk, and forced the waters around through the Schoharie valley and out by the Knox and Delanson passes. In this third stage the ice front weakened on the Rotterdam salient so as to allow outflow by Rotterdam Junction and South Schenectady.

Theoretically the stream work of this stage must begin at a level below that of the Delanson channel, or 840 feet. At Pattersonville this plane might be 860 feet. Examination of the locality finds the facts in accord with the philosophy. The face of the hill three miles north of South Schenectady, forming the point of the great triangle between the Mohawk and Normanskill valleys, is strongly terraced and gullied down to 360 feet. The hollow on the northwest side of the hill contains a handsome channel at 580–600 feet. The face of the next hill shows stream work up to about 700 feet. The col between the heads of the Plotter kill and the Poentic kill is occupied by uncut moraine drift.

The general history of the ice recession in this district seems clear. The ice margin curved around the Rotterdam salient, with a

lesser tongue pushing up the Mohawk gorge and a larger lobation in the low ground to the southwest. The ice seems to have pressed against the slope west of South Schenectady while it weakened northward and opened the 600 feet gap between the two hills near the Mohawk, in such manner that the col at the head of the Plotter and Poentic kills was not subjected to stream cutting.

The detritus carried by the higher flow across the Rotterdam salient must have been swept on in confined waters, around the ice lobation, through Altamont and southward to quiet waters in the Hudson valley. The detritus of the later flow seems to have contributed to the sand plains about South Schenectady, with altitude of 340 feet.

The south wall of the Mohawk at Rotterdam Junction may have been undercut and steepened by glacial flow crowded against the slope.

Area and sand plains. Plate 15 shows the hypothetic extent of the lake as mapped for its middle phase. On account of its lower altitude the Amsterdam waters formed only a relatively narrow body in the Mohawk and Schoharie valleys, especially for the later phase. In the Rome district the waters spread more widely along the receding Ontarian ice; north of Fonda and Amsterdam they reached so as to flood the Sacandaga and upper Hudson valleys, as long as the lake stood over about 760 feet, below which the Sacandaga held a tributary lake (see page 35).

Allowing for deformation the higher plane of the waters in the district of the Lansing kill and upper Mohawk should be 70 feet over the Schenectady outlet, or up to about 900 feet. On the parallel of Rome the uplift is 60 feet and the latest plane would be about 420 feet.

The delta plains built in the Amsterdam waters by tributary drainage occur widely distributed over the basin and agree with the theoretic levels. The most massive deposits are naturally found at the debouchment of the heavy streams. On West Canada creek, south of Trenton village, the sand plains are from 880 down to 740 feet, being partly contributed by drainage from the Lansing kill lake. On East Canada creek, south of Dolgeville, the plains are from 800 feet down. At Johnstown are water levels at about 700 feet. In the Sacandaga valley are excellent terraces and extensive plains, shown in plate 8. North of the village of Northville is a fine plain at 860 feet. The plains of Northville and of Sacandaga Park are 800 feet. The higher levels of the broad plains south of Northville extending five miles to the Great Vly, declining from 800

to 720, belong to the Amsterdam lake; below about 780 they belong to the Sacandaga tributary lake. All the above figures are from the map contours.

In the narrow Mohawk valley the lowest levels are the most prominent, being the accumulations of detritus by downwashing into the bottom of the valley and leveling by the later waters. These plains include all the level stretches which are so conspicuous from the railroads in the valley. Following are some of the occurrences: at Oriskany, both sides of the valley, at 520–540; Frankfort, 500; Ilion, 500; Herkimer, 520; Fonda, 420–460; Tribes Hill, 420–440; Amsterdam, 420–440; near the mouth of Schoharie creek from 420 down. The most extensive plains lie north of Rome (plate 2), built by the heavy ice-border drainage along the north side of the ice lobe, at 600 down to 460 feet.

The occurrence of the lake plains in the Sacandaga valley and the lower Mohawk have been noted by Professor Brigham, and correctly attributed to a Mohawk lake, but without determination of the outlet channel (see title 6, pages 26–28).

FIFTH STAGE: LAKE ALBANY

The name Lake Albany has been given by Professor Woodworth to the body of water held in the Hudson valley in the Albany region in which were deposited the widespread sands and clays, partly shown in plate 6. This lake and its relations are described in State Museum Bulletin 84 (see title 40), and it is not the province of the present writing seriously to discuss the Hudson-Champlain lake history. Woodworth regards the Albany waters as lying against the receding ice front northward over the Fort Edward district as far as Fort Ann, and as extending south in a narrowing strip of water probably to Kingston. He supposed that the barrier on the south was due to elevation of the lower Hudson a few hundred feet above its present level, with probably some obstruction by morainal drift in the gorge of the highlands. The final draining of the lake he suggests might have been due to the removal of the drift barrier by the greatly increased volume of water when all the overflow of the Great Lakes was turned through the Mohawk valley, in Iroquois time.

The broad plains at South Schenectady, which we may consider the head of the Albany delta plains, are 340 feet elevation. Somewhat interrupted by glacial drift the lake plane steadily declines until at South Bethlehem, near the bottom of plate 6, it is 200 feet; and at Coeymans the deposits terminate at 160 feet.

Mohawk rivers. A very long time intervened between the extinction of Lake Amsterdam, establishing free drainage through the Mohawk valley, and the beginning of the present river. That interval was the glacial flow that endured until the Laurentian ice body weakened north of the Adirondacks sufficiently to open an escape for Lake Iroquois on the international boundary,[1] across Covey hill, lower than the Rome outlet.

Two periods of the glacial flow have been discriminated by the writer; one called the Glaciomohawk, which covered the flow previous to the establishing of Lake Iroquois, and the Iromohawk, the outflow of the Iroquois waters (see title 17, p. 38). The Glaciomohawk river endured while the central New York waters passed through four stages: the later Lake Vanuxem, the free drainage succeeding Vanuxem, the restored Vanuxem and Lake Warren (see State Mus. Bul. 127, plates 37–40). It is possible that the readvance of the ice front in the Syracuse district, during Second Vanuxem and Warren time, was accompanied by contemporary advance of the Hudsonian lobe so as again to block the Mohawk and produce a second Lake Amsterdam, but it is now only conjecture.

The Iromohawk endured from the time when the ice left the Rome district to the time when it had abandoned the Ontario basin and lay against Covey hill, on the north boundary of the State.

The volume of the Glaciomohawk was always much greater than that of the present river, and for part of its life it received all the drainage of central New York from as far west as LeRoy. The Iromohawk was a larger river than the St Lawrence. It not only carried the precipitation of the St Lawrence basin but received in addition the contribution from the melting of the accumulated ice body.

Remnants of the Iromohawk flood plains in the form of low terraces occur along the valley, especially near the junction of larger tributaries. They range in altitude from 440 feet at Utica to about 380 at Amsterdam and 360 at Schenectady.

The relation of Lake Albany to the glacial Mohawk is not clear. With the recession of the ice front from Schenectady we lose the key to correlation which we possessed during the earlier history, in the relation of ice-border channels to lake planes. The capacity of the intrenched channel of the river below Schenectady seems insuf-

[1] Science, XXVI, 399; Sept. 27, 1907. Also (title 40) N. Y. State Mus. Bul. 84, p. 161–64, pl. 25.

...urable to the St Lawrence. It seems prob-
...ay endured to the close of Iroquois time.

...ents and deformation. The present river from ... feet) to Schenectady (210 feet) falls 210 feet in 92 ...y the line of the valley (not counting the stream meanders), ...ich gives 2.3 feet per mile. The actual slope of the river is much less above Herkimer. At and below Schenectady the river has intrenched itself about 130 feet below the head of its ancient delta, the Lake Albany plane. The Iromohawk river must have poured its flood across the delta, now 340 feet in elevation at South Schenectady. The col at Rome is now 430 feet. From this we must deduct about 55 feet for 27 miles of northing, making 375 feet the altitude of the head of the later Iromohawk channel. This gives a fall of 35 feet in 92 miles, or a gradient of 0.38 feet per mile. The elevation of the highest wave-built bars and spits in the Iroquois basin near Rome is 460 feet (see plate 2),[1] which gives 30 feet of water over the sill of the channel head, which is a normal depth for the great river. If we allow the same depth of water at the mouth of the river, and the South Schenectady deposits are fine, indicating submergence, we have the same moderate grade as for the channel bottom. These figures accord well with the grade of large rivers and indicate that our estimate of the deformation is fairly correct.

In the comparison of channels and lake plains in central New York and the Mohawk valley we find the northward uplift to be about 2 feet per mile, perhaps a trifle more. Hence if we allow this amount of uplift on the Rome meridian there is no balance left for east and west deformation. It is positive that through central New York, from Sodus to Rome, there is no appreciable east-west tilting since Iroquois time,[2] and it seems quite certain that the uniformity extends east to the Hudson; in other words, that the isobasal lines have here approximately east and west direction.

TRIBUTARY LAKES

Besides the Black valley waters which during most of their life were tributary to the Mohawk waters, as already described, other lakes were held at high levels along the margins of the ice lobes and found escape into the Mohawk. The lakes held in the valleys between Syracuse and Utica were described in the Twenty-second

[1] The writer is indebted to Mr F. B. Taylor for first drawing attention to these features.

[2] See N. Y. State Bul. 127, p. 55.

Report of the State Geologist for 1902 (see title 17). Similar to these waters held along the south margin of the lobe were other local waters on the north side.

The high ground between the Ontario basin and the Black valley must have emerged from the ice sheet as an island in the broad water (plate 13). When this land mass became connected with the exposed land on the southeast (plate 14), or even earlier, the land drainage and the glacial outwash passed around the periphery of the open area until it reached the Mohawk escape. The greater portion of the high area is today drained westward by the numerous branches of North Sandy and South Sandy creeks, Salmon river and lesser streams, and southward by the west and east branches of Fish creek and the Mohawk river. All this heavy drainage was blocked by the ice during the time shown in plates 14–16. Each valley must have held its lake, and these poured from one into the other across the intervalley ridges until the augmented water reached the Mohawk valley. An example of such transverse channels is indicated in plate 4, in the vicinity of Lorraine east of Adams. The fragmentary channels here noted belong to a late stage of the ice recession in the district, but similar cross-ridge channels must of necessity occur higher on the slope and of earlier time. Plate 2 shows one strong channel of the earlier drainage lying between Fish creek and the upper Mohawk. No attempt is made to map the minor channels, to do which will require close examination of large territory.

Lansing kill lake. These few channels in plate 2, between Fish creek and the Mohawk, point us to the story of a distinct lake in the upper Mohawk district. When the ice margin had the position that is shown in plate 15 it formed an east-west dam lying on Quaker and South hills. All the west and south drainage of the highland east of Ontario basin flowed along the ice edge, producing larger ponding in the two valleys of Fish creeks, and outflowing at Point Rock into the Mohawk and then into the Lansing kill lake. This was subsequent to the opening of the Remsen channel, but while the St Lawrence glacier was pushing a lobe up (south) the Black valley. It will be remembered that earlier the Lansing kill waters had been a branch of the Forestport lake, the connecting strait being the head of the Lansing kill valley, north of Potato hill. The time here recorded is that of the Port Leyden stage in the Black valley and the late Schoharie and early Amsterdam stage in the Mohawk basin. A profusion of delta terraces are found in the upper Mohawk-Lansing kill basin which fall into three categories;

a few of the highest, ranging above 1200 feet, probably represent the Forestport level, while those from 1200 down to about 900 feet belong to the Schoharie lake, which seems to have entered the basin through the Steuben valley northwest of Trenton. Below 900 feet the terraces must correlate with the Amsterdam waters, or below 830 feet (the Steuben col) with the local lake.

The ice seems to have lingered on the southwest flanks of Quaker and South hills while the Schoharie lake fell to the Amsterdam lake, and then the Lansing kill river extended itself through the Steuben valley.

When the ice weakened on the flank of Quaker hill the ponded waters of Fish creek and tributaries found their outflow through the splendid series of strong channels west and east of Lee Center; and at the same time, the ice waning on the western slope of South hill, the waters found their ultimate escape by channels at Delta, Floyd and Marcy, at 600 to 500 feet, into Mohawk waters of late Amsterdam stage. These features are shown in plate 2.

As the Port Leyden lake (Copenhagen outlet, see page 13), following the suppression of the Boonville river, was probably as late as early Iroquois time, and as the initiation of Lake Iroquois was in the Rome-Oneida district, it follows that the Lansing kill and upper Mohawk valleys held glacial waters from at least the time of Forestport lake down to initiation of Iroquois. The ice here made its most determined stand, at the head of the Mohawk valley; and the consequent production of channels and deltas make it the critical locality for correlation with similar effects of the ice barrier at the east end of the Mohawk valley.

Of the many marginal lakes, mostly small, which the ice held on the north and the south slopes of the Mohawk valley only one will be described here, though a close study will discover many interesting details of the history.

Sacandaga lake. A large lake tributary to the Mohawk waters was held in the Sacandaga and upper Hudson valleys. From its sources in the southeastern Adirondacks this river enters a broad valley at Northville and at Northampton turns northeast and joins the Hudson at Luzerne. During all the time covered by this history the Hudson drainage was blocked by the Hudsonian ice lobe and the waters of all the Adirondacks were forced into tribute to the Mohawk lakes. During the life of the Schoharie lake the ice lay across the upper Hudson somewhere in the district of Corinth, covering the area of Saratoga and Ballston, and the Schoharie waters must have flooded the territory of Johnstown, Gloversville,

Northville and the canyon of the upper Hudson, so much as then existed. These waters at their lowest level must have been 840 plus 70 feet for tilting, making the water 900 feet at Northville and Corinth. The Sacandaga at Northville is now 740 feet, and the Hudson at Corinth is today only 520 feet.

When the Schoharie lake was succeeded by the Amsterdam lake the Hudson valley was still blockaded and the lake covered Northville; but when the Amsterdam water fell to about 750 feet, on the Gloversville parallel, the Sacandaga-Hudson waters became a distinct lake, with outlet southward by a pass four miles southeast of Gloversville, at 760 feet. For two miles below the col this outlet is a fair channel, but half way to Johnstown it becomes narrow, though in shale, and unsatisfactory as an outlet channel of a large lake. However, with the present conception of the events connected with the ice recession it seems positive that the Sacandaga-Hudson waters must have outflowed here into Lake Amsterdam. This tributary lake must have persisted until the recession of the ice in the Saratoga and Ballston district opened a lower escape for the Hudson waters at South Corinth. The Saratoga topographic sheet shows the pass at South Corinth, at 636 feet, leading southward to the Kayaderosseras creek. The valley of this stream shows excellently the work of a short-lived river of high gradient and large volume. Below Middlegrove and at Rock City Falls the valley walls are severely cut and heavy deposits of coarse cobble detritus lie far above the present stream. The very extensive sand plains at Ballston Spa and northward are the delta built by the glacial Hudson, debouching at above 400 feet altitude in the late Amsterdam or early Albany lake. This escape of the Hudson waters would seem to have existed as late as the close of Lake Amsterdam and the establishment of Lake Albany over the Schenectady district.

The name for this lake was given by Professor Brigham, who has briefly described the Northville deltas (see title 6, pages 26, 27). Plate 8 indicates in a general way the features of the Northville district.

THE ROCK BARRIER AT LITTLE FALLS

One questionable factor in the glacial history is the effect on the drainage and the time of the downcutting of the rock col at Little Falls.

In a former paper (see title 17, pages 22, 30–33) the writer attributed some features in the Mohawk valley above Little Falls to the ponding effect of the rock barrier, with perhaps some help

EDUCATION DEPARTMENT
JOHN M. CLARKE
STATE GEOLOGIST

UNIVERSITY OF THE STATE OF NEW YORK
STATE MUSEUM

BULLETIN 160 PLATE 8

GLACIAL WATERS IN THE MOHAWK AND SACANDAGA VALLEYS

H. L. FAIRCHILD
1909

Scale 1/62500
0 1 2 3 Miles
Contour interval 20 feet.
Datum is mean sea level.

BENSON
HAMILTON CO.
FULTON CO.
NORTHAMPTON
SARATOGA CO.
FULTON CO.
SACANDAGA RIVER

Northville
Edinburg
Sacandaga Park
Bunker Hill
Osborn Bridge
Cranberry Creek
Northampton (Fishhouse)
Benedict
North Broadalbin
Mussonville

Buell Mt.
Gifford Valley
Glowersville
Thurman Ridge
Johnstown
Maxfield
Frenchman
Creek
Cayadutta Creek
Ephratah
Broadalbin
Stony Creek
Kennyetto Creek
Sacandaga
Butler
Creek
Fonda
Johnstown
Gloversville
Northville
Edinburg
Sacandaga Park
Bunker Hill
Osborn Bridge
Cranberry Creek
Northampton
Benedict
North Broadalbin
Mussonville

B.M. 763
B.M. 789
783
766
755
805
800
788
787
782
964
960
956
926
743
741

LEGEND

DELTAS AND SANDPLAINS

- *Scholarie lake*
- *Sacandaga lake*
- *Amsterdam lake*

INTERPRETATION

COMPARE MAPS, PLATES 14-15

Only a few of the lake plains are mapped. Other high delta plains must exist between Northville and Edinburg. The swamp areas are probably detrital fillings in the lakes.

from morainal drift and lake deposits. Later study makes that conclusion seem improbable.

The lacustrine plains and terraces in the upper Mohawk and north of Rome are now found to correlate with the glacial lakes held in the whole extent of the Mohawk valley by the Hudsonian ice lobe. While the ice lay over Rome there was drainage past its northern edge at as low elevation as 500 feet; and as early in the glacial lake history of central New York as the close of Lake Vanuxem (see title 19, page 57 and plates 37, 38) there was free eastward flow through Syracuse as low as 400 feet, present altitude. The low altitude of the Syracuse passes as compared with the Rome col, 430 feet, seems partly due to the northerly position of Rome, some 12 miles, which gives at least 25 feet of relative uplift for the Rome parallel.

In plates 15 and 16 of this paper we make the low Syracuse drainage correlate with Lakes Amsterdam and Albany. It could not have been earlier than this stage, unless in some deglaciation interval as yet unrecognized. It does not seem probable that it was later, because lying in time between this and Iroquois time in central New York is the readvance of the ice at Syracuse and the considerable period of Lake Warren and the Hyper-Iroquois waters. We must not assume too great difference between the waning of the ice fronts in the Syracuse and the Albany districts.

It does not seem possible that any considerable lowering of the hard rock barrier at Little Falls could have been accomplished by the moderate flow during merely the closing phase of the Amsterdam lake. But this seems imperative if we attribute all the cutting to that one episode of lowering waters; for when the outflow on the Rotterdam salient was under 600 feet the Little Falls pass was under Amsterdam lake water, and at what now appears to have been the end of the Amsterdam stage the pass was as low as it is now.

It is believed that the glacial phenomena in New York are not the work of a single ice invasion but the product of two or more invasions. This being conceded it follows almost certainly that the production of glacial lakes must have been repeated, and the probable outflow have been similar to the latest. In this view the large drainage channels were not wholly cut by the latest rivers. In accordance with the above it seems altogether probable that the rock barrier at Little Falls was chiefly or entirely cut by Prewisconsin drainage, and that the Glaciomohawk and Iromohawk[1] rivers had

[1] These names for the glacial river were given in 1904. See title 17, p. 38.

only to remove some filling of drift and do a small amount of rock cutting to produce the present pass. The rock shelves were probably cleared of drift and exposed as we now find them (title 17, plates 13–25) by wave action of Lake Amsterdam waters.

This fact is certain, that the Little Falls pass was cut to nearly its present depth while the ice lay over Rome, and far antedating the time when the flood from the Great Lakes poured through the valley. We are compelled to the conclusion either that the trenching was Prewisconsin or that the Mohawk drainage history connected with the Wisconsin ice retreat is much more complicated than we can now appreciate.

THE DIVIDE AT ROME

Closely connected with the problem of the rock pass at Little Falls is that of the divide at Rome. It is a singular fact that the col or divide at Rome, the place of outflow of Lake Iroquois, on which headed for many thousand years a river as large as the St Lawrence, is not rock but detritus, gravel, sand and clay. This lake and stream deposit has a large area (see plate 2) and extends down the Mohawk valley about 30 miles. Well borings at Rome (see title 5, page 190) show that the depth of these water-laid deposits is considerable, in places over 100 feet. Brigham gives the rock bottom at Rome as 320 feet, and at Little Falls 376 feet. It appears that if the valley were cleared out to the rock the Mohawk river would head at Little Falls and that a lake would occupy the ground west of that point.

It has long been recognized that in Preglacial time the drainage divide was at Little Falls (see title 8, page 362) and that the water west of Little Falls was tributary to a trunk stream in the Ontario valley. It seems probable that in the earliest flow of the Glaciomohawk the stream headed at Little Falls while the valley westward was occupied with quiet or lake waters, though it may have been filled by glacial drift. However, any waters of the narrow lake would have been soon displaced by the abundant detritus swept in by the ice drainage and West Canada river and the conditions changed from lacustrine to fluviatile. As the ice lobe melted back, westward, the detrital filling probably followed it.

The deep alluvial deposit at Rome, which now creates the divide between St Lawrence and Mohawk drainage, is the delta built by the heavy glacial drainage from the north and northwest during Lake Amsterdam time (see plates 2, 15, 16). During all the life of Lake Iroquois the detrital contribution of the upper Mohawk seems to have been sufficient to block the outflow and to establish the

wasteweir or stream head at Rome. A little cutting would today divert the flow of the Mohawk westward into Wood creek.

SUMMARY OF THE MOHAWK DRAINAGE HISTORY

Stage 1. The axis of the valley was occupied by a strait of ice connecting the two ice bodies in the Hudson and Ontario valleys. The waters of the Adirondacks escaped across the ice, the overflow probably being into the Otsego-Susquehanna valley. Sand plains through the Adirondacks with elevation 1450 and upward probably correlate with this stage. See plate 12.

Stage 2. The melting of the strait of ice in the valley left a stretch of open water between the ice tongues, the Herkimer lake. The water had two successive outlets, by Summit lake pass to the Otsego-Susquehanna at 1360 feet, and by the Cedarville pass to the Unadilla-Susquehanna, at 1220 feet. Correlating sand plains of great expanse occur in the basins of the upper Mohawk, West Canada and East Canada creeks at 1440 to 1280 feet. See plates 2, 5, 7, 13. The Black valley basin was flooded by the waters of this stage, so far as relieved from the ice sheet.

Stage 3. Waning of the Hudsonian ice lobe permitted escape of the waters along the face of the Helderberg scarp, west of Albany, the later flow being across the divide between the Schoharie and Hudson valleys, at Delanson, 840 feet. Correlating sand plains exist in many localities with elevation, according to latitude, from 1200 down to 820 feet. See plates 2, 7, 8, 14. The Black valley waters were now tributary to the Schoharie lake, first through the Remsen outlets and later by the Boonville outlet, as shown in plate 2.

Stage 4. Amsterdam lake. Further recession of the Hudson valley ice lobe permitted outflow of the waters about the Rotterdam salient, west of Schenectady, at 800 down to 360 feet. See plate 6. The correlating delta plains are widely distributed, having altitude in the Rome district of 860 to 460 feet. See plates 2, 8, 15. The Black valley waters were still tributary and two other tributary lakes were the Lansing kill and the Sacandaga. See plate 8.

Stage 5. Lake Albany, confined to the Hudson valley, with outlet control southward. The Mohawk valley now had free drainage, two phases being the Glaciomohawk, previous to Iroquois time, and the Iromohawk, the overflow of Lake Iroquois.

CORRELATION OF THE ONTARIAN AND HUDSONIAN ICE LOBES

Maps of the waning ice sheet. Plates 9–17

The criteria or data for determination of the positions of the ice fronts and the construction of the maps are found in the following facts:

1 Deltas or sand plains indicate approximate heights of lake surfaces and prove that open water existed at the locality when the deposits were laid, the ice being removed.

2 Stream channels indicate approximate heights of the outflowing lake, with some allowances for depth of the rivers, and imply lower levels for the receiving waters. Streams across cols must be lake outlets.

3 A series of stream-cut channels on a land slope imply a lowering barrier, the receding ice front holding the streams to their work.

4 A channel in the bottom of a col or valley with no stream work on the wall of the valley indicates that standing or open water was lowered on the valley until flow was established across the divide.

5 The border of the glacier must have had general uniformity of height, resting like a lake or river against the land, but with some rise toward the source of supply and declining downstream.

6 In comparison of features relating to lake planes some deformation of the land must be recognized.

Contemporaneous positions of the two ice fronts, far separated in the Ontario and Hudson valleys, have been quite definitely determined in a few localities by means of criteria noted above. In the Ontario basin near the head of the Mohawk valley we find an abundance of glacio-lacustrine phenomena which must have altitude relation to the eastward escape of the same lake waters; and it is found that such eastward outflow was controlled by the glacier in the Hudson valley. When the outlet channels are along a steep slope, like those on the face of the Helderberg scarp or on the hills west of Schenectady, we may be sure of the precise position of the ice front there at the time when the imprisoned lake had corresponding altitude. At the Ontario end of the lake the positions of the ice front can be determined approximately by means of inflow channels and deltas, in their relation to the lake surface. For example, the deltas at Trenton and Trenton Falls indicate subsiding lake waters,

and the correlating outlets can be nowhere except through the Delanson hollow and on the face of the Helderberg scarp, where the ice-compelled rivers have left their unmistakable tracks. At Lee Center, northwest of Rome, and eastward are sluggish-flow channels at declining levels, made along the stagnant ice margin, while the lake levels were controlled by the ice front on the Rotterdam salient.

From localities of known position for the ice margin the latter can be extended theoretically, lapping on the land at levels slowly rising northward and falling southward.

Between known positions of the ice at different periods the location for time intermediate can be approximately interpolated.

The maps (plates 9–17) are an attempt to portray several stages in the recession of the latest ice sheet. A continuous waning of the glacial lobes is suggested by the maps. However, the ice sheet did not pass away by continuous and steady recession but by oscillations, readvances and reretreats; and some of the readvances may have covered considerable territory and have seriously changed the drainage. At present our knowledge of these elusive changes in the glaciers in the Mohawk-Hudson region is almost nothing and no account can be taken of them.

The maps make no claim to accuracy, except at a few points for a few stages in the history. They are only suggestive and intended to give in a graphic way the broad facts in the general history. The positions of the ice limits as indicated in the maps are separated by long periods of time, perhaps in some cases thousands of years, during which oscillations of large extent may have occurred. The positions of the ice fronts at both ends of the Mohawk valley are definite for the phases shown in plates 14–16.

These maps are an extension and correction of plates 34–42 of the preceding paper (N. Y. State Museum Bulletin 127) on Central New York drainage.

Between the stages depicted in plates 16 and 17 is a very long interval unmapped. During this time central New York had a varied lake history, including at least the Second Vanuxem, Warren and Hyper-Iroquois waters. If the ice in the Hudson advanced in sympathy with that in the Syracuse district it may have again blocked the Mohawk valley. But with the beginning of Lake Albany we have no means, now recognized, of comparing the limits of the ice in the Hudson valley with those in the Ontario. Rather than depict stages between those of plates 16 and 17 in a purely

hypothetical way, they are omitted. In plate 17 the limits of the Champlainic ice lobe is a matter of conjecture.

It is only hoped that these maps will serve as suggestion and stimulus to more detailed study of the glacial phenomena, and that the future student may be able to translate much more of the wonderful history.

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The following list includes writings which have some reference to the physiography, surficial geology and Pleistocene history of the region. Papers that discuss only the stratigraphy or paleontology of the region are not included.

A list of papers relating to the region adjacent on the west may be found in the latest paper by the writer (title 19) and an extended list bearing on the Pleistocene of New York and the Champlain-Hudson district in particular is contained in Professor Woodworth's paper on the Champlain and Hudson valleys (title 40).

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STAGES IN THE
WANING OF THE ICE SHEET
IN
NEW YORK STATE
H. L. FAIRCHILD
1909

STAGE 1.

Maximum extent of the glacier during the latest (Wisconsin) glacial epoch.

Scale of Miles

10 5 0 10 20 30

STAGES IN THE
WANING OF THE ICE SHEET
IN
NEW YORK STATE
H. L. FAIRCHILD
1909

STAGE 2.

The ice border lies along the Susquehanna valley. The indicated limit in the Hudson valley is hypothetical. Highest peaks of the Adirondacks and the highest hills along the ice margin appear above the ice cap. A glacial lake lies in the Genesee valley with outlet to the Allegany-Mississippi.

Scale of Miles
10 5 0 10 20 30

STAGES IN THE
WANING OF THE ICE SHEET
IN
NEW YORK STATE
H. L. FAIRCHILD
1909

STAGE 3.

Represents the moraine at Portage, and the Valley-Heads moraine in the Finger lake valleys. The Adirondack highlands are partially exposed. Glacial lakes in the Genesee and Cattaraugus valleys have outflow to the Susquehanna and Allegany drainage. The glacial waters in the Adirondack area had no escape except across the neck of ice in the Mohawk valley into Susquehanna flow. Local glacial lakes lay along the border of the Hudsonian lobe, but are not shown here.

Scale of Miles

STAGES IN THE
WANING OF THE ICE SHEET
IN
NEW YORK STATE
H. L. FAIRCHILD
1909

STAGE 4.

The ice front lies across the valleys of the Finger lakes. Many local glacial lakes are held in valleys sloping toward the ice. The Adirondack waters, which are not mapped, find escape across the ice strait in the Mohawk valley into Otsego-Susquehanna drainage. The glacial waters in the Hudson valley are not mapped. In the Erie basin Lake Whittlesey is invading the State, with outlet to the Mississippi. The ice borders about the Adirondacks and in the Hudson valley are generalized.

Scale of Miles

10 5 0 10 20 30

STAGES IN THE
WANING OF THE ICE SHEET
IN
NEW YORK STATE
H. L. FAIRCHILD
1909

STAGE 5.

The ice front lies along the north ends of the Finger lake valleys. Lake Newberry, the expansion of Lake Watkins, replaces all the local lakes in the valleys from Skaneateles to the Genesee. Lake Herkimer lies in the Mohawk and Schoharie valleys, and receives all the Adirondack drainage, having outlet by the Unadilla-Susquehanna; an early phase being shown here. Lake Whittlesey in the Erie basin has acquired its greatest extent.

Scale of Miles

10 5 0 10 20 30

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BULLETIN 160 PLATE 14

STAGES IN THE
WANING OF THE ICE SHEET
IN
NEW YORK STATE

H. L. FAIRCHILD

1909

STAGE 6.

The ice front has receded somewhat from the position of stage 5. Lake Hall, the successor of Newberry in the central district is tributary to Lake Warren, the successor of Whittlesey in the Erie-Huron basin. Lake Schoharie, the successor of Herkimer in the Mohawk-Schoharie valleys, has outlet along the Helderberg scarp to the Hudson valley, a late phase being depicted here. No drainage across the southern divide. The waters in the Hudson valley are not shown.

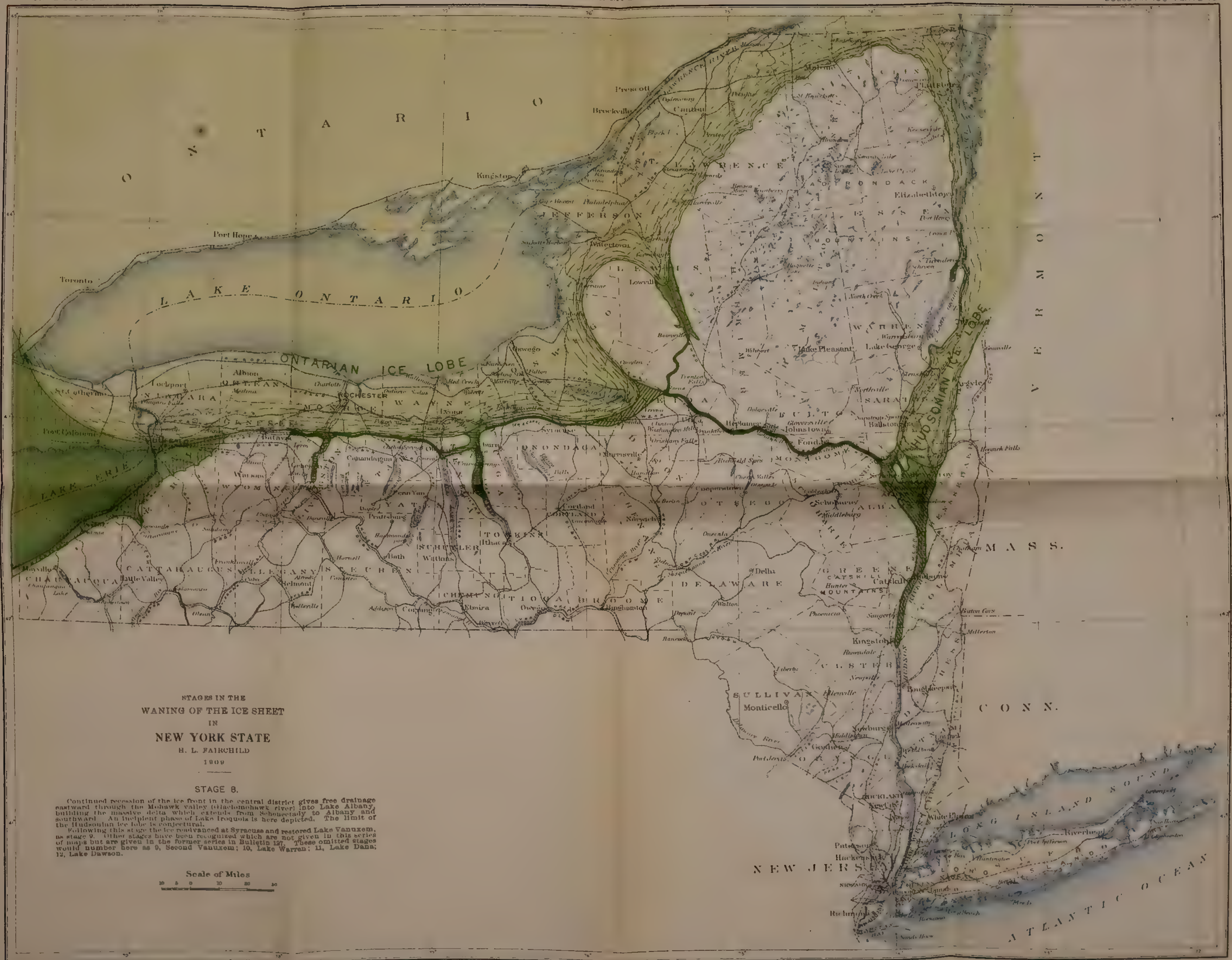
STAGES IN THE
WANING OF THE ICE SHEET
IN
NEW YORK STATE
H. L. FAIRCHILD
1909

STAGE 7.

The Ontarian Lobe has slightly receded in the Syracuse district while remaining stationary in the Batavia district. Lake Vanuxem, the successor of Hall, drains east to the Mohawk, where Lake Amsterdam, the successor of Schoharie, has outlet by South Schenectady and along the base of the Helderberg scarp to the glacial Lake Albany in the Hudson valley. Two glacial lakes, tributary to the Mohawk waters are Lansing Kill and Sacandaga. Port Leyden lake occupies the Black valley, with outlet into the Lansing Kill lake.

Scale of Miles

10 5 0 10 20 30



STAGES IN THE
WANING OF THE ICE SHEET
IN
NEW YORK STATE
H. L. FAIRCHILD
1909

STAGE 8.

Continued recession of the ice front in the central district gives free drainage eastward through the Mohawk valley (Hlacktomohawk river) into Lake Albany, building the massive delta which extends from Schenectady to Albany and southward. An incipient phase of Lake Iroquois is here depicted. The limit of the Hudsonian ice lobe is conjectural.

Following this stage the ice readvanced at Syracuse and restored Lake Vanuxem, as stage 9. Other stages have been recognized which are not given in this series of maps but are given in the former series in Bulletin 127. These omitted stages would number here as 0, Second Vanuxem; 10, Lake Warren; 11, Lake Dana; 12, Lake Dawson.

Scale of Miles

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BULLETIN 160 PLATE 17

STAGES IN THE WANING OF THE ICE SHEET IN NEW YORK STATE

H. L. FAIRCHILD

1909

STAGE 13.

Continued recession of the ice permitted Lake Iroquois to occupy the Ontario basin, with outlet at Rome by the Iromohawk river. Lake Albany has spread north in the Hudson valley. Glenfield lake in the Black valley, the successor of Port Leyden lake, has outlet westward into Lake Iroquois at Adams.

A yet later stage in the ice recession (No. 14) permitted Lake Iroquois to find a lower outflow north of the Adirondacks into Champlain waters. With final recession, sealevel waters occupied the Ontario basin, known as Gilbert gulf, a branch of the Champlain or Hochelagan sea.

Scale of Miles

10 5 0 10 20 30

FLORIDA
GLENVILLE
CLIFTON PARK
ROTTERDAM
SCHENECTADY
DUANESBURG
NISKAYUNA
ROTTERDAM
COLONIE
GUILDERLAND
KNOX
WRIGHT
BERNE
BETHLEHEM
WESTERLO
NEW SCOTLAND
ALBANY
Princetown
Watervliet
Duanesburg
Rotterdam
Glenville
Niskayuna
Colonie
Guilderland
Knox
Berne
Bethlehem
Westerlo
New Scotland
Albany
BOUNDARY LINE
SCHENECTADY CO
ALBANY CO
GLACIAL WATERWAYS
IN THE
MOHAWK AND HUDSON VALLEYS
H. L. FAIRCHILD
1900
LEGEND
GLACIAL STREAM CHANNELS
DELTA OR KAME PLAIN
INTERPRETATION

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BULLETIN 1, PLATE 2

GLACIAL WATERS IN THE BLACK AND MOHAWK VALLEYS

H. L. FAIRCHILD

1898

LEGEND

MORAINES

GLACIAL STREAM CHANNELS

DELTAS OR SANDPLAINS

WAVE-WORK OF LAKE IROQUOIS

INTERPRETATION

For explanation, see PLATE 1.

LEYDEN
LEWIS
BONNIEVILLE
FORESTPORT
WILMURT
WEST TURIN
MARTINSBURG
WEST LEYDEN
WEST LEE
LEE
TURIN
ROME
VIENNA
FLOYD
TREMONT
RUSSIA
MARCY
DEERFIELD
NEW PORT
WHITESTOWN
ONEIDA LAKE
BUCK HILL
QUAKER HILL
WORCESTER HILL
BOONVILLE HILLS
MOHAWK RIVER
WEST CANADA CREEK

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BULLETIN 160 PLATE 3

GLACIAL WATERS IN THE BLACK VALLEY

H. L. FAIRCHILD

1909

LEGEND

DELTAS OR SANDPLAINS

Port Leyden lake

Glenfield lake

KETTLES IN SANDPLAINS

INTERPRETATION

COMPARE MAPS, PLATES 15-17

The steep slopes of the east side of the valley are the delta sands, eroded by present agencies. Only the more prominent of the Glenfield lake terraces are indicated.

The apparent terraces on the west wall of the valley are rock (limestone) benches, with little drift and slight lake deposits.

Scale 1/62500

1 0 1 2 3 Miles

1 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.

Datum is mean sea level.

GLACIAL WATERS
IN THE
BLACK AND ONTARIO VALLEYS
H. L. FAIRCHILD
1909

LEGEND

GLACIAL STREAM CHANNELS

- Channel with both banks preserved
- Channel with south bank only, the north bank having been the ice
- Channel hypothetical, or with indefinite borders

DELTAS

- Glenfield lake
- Iroquois lake
- Redman (local) lake

WAVE-WORK OF LAKE IROQUOIS

- Bars and spits
- Cliffs

INTERPRETATION

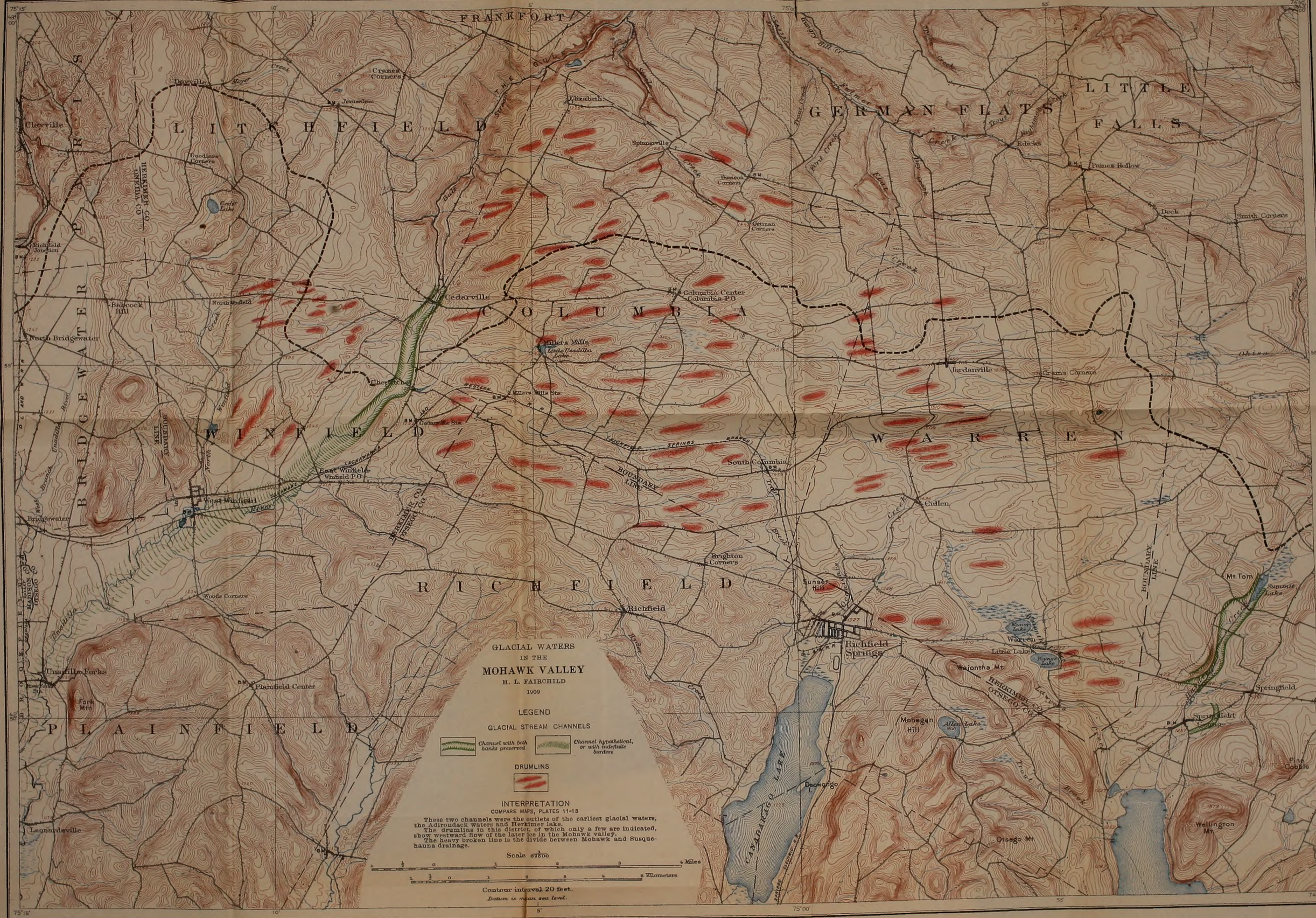
COMPARE MAPS, PLATES 16-17

The channels in the town of Harrisburg carried the waters of the glacial lake in the Deer valley eastward into Glenfield lake. All the other channels carried the falling waters westward around into lake Iroquois. The Iroquois shoreline is undetermined in the valley of Black river.

PAMELIA
LERAY
WATERTOWN
RUTLAND
CHAMPION
WILNA
CARTHAGE
DENMARK
RODMAN
PINCKNEY
HARRISBURG
LORRAINE
WORTH
MONTAGUE
MARTINS

Watertown
Watertown Center
Rutland Center
Rutland Lake
Pleasant Lake
South Champion
Deer River
Dennmark
High Falls
Carthage
West Carthage
Mt. McQuillen
Stowell Corner
North Adams
Adams Center
Adams
Honeyville
Whitford Corners
Green Settlement
Rodman
Allendale
Lorraine
Worth
Pinckney
Barnes Corners
Trenames Corners
Worth Corners
New Boston
Bellwood
Windecker
Harrisburg
Montague
Carpenters Corners
Rector
Lanesburg
Huntington Mills
Bourne Mills
Wheeler
East Rodman P.O.
Klondike
Wirth P.O.
Texas
South Ford Mill P.O.
Champion Mills
Champion Corners
Deer River P.O.
Stony Creek
Black River
Deer River
Crooks Creek
Gulf
Sandy Creek
Mad Brook
Indian River
Kings Falls
Jefferson Co
Lewis Co

Scale 62500
1 0 1 2 3 4 Miles
1 0 1 2 3 4 5 Kilometers
Contour interval 20 feet.
Datum is mean sea level.



GLACIAL WATERS
IN THE
MOHAWK VALLEY
H. L. FAIRCHILD
1909

LEGEND

GLACIAL STREAM CHANNELS

Channel with both banks preserved

Channel hypothetical, or with indefinite borders

DRUMLINS

INTERPRETATION

COMPARE MAPS, PLATES 11-13

These two channels were the outlets of the earliest glacial waters, the Adirondack waters and Herkimer lake.

The drumlins in this district, of which only a few are indicated, show westward flow of the later ice in the Mohawk valley.

The heavy broken line is the divide between Mohawk and Susquehanna drainage.

Scale 1/62500

0 1 2 3 4 Miles

0 1 2 3 4 5 6 Kilometers

Contour interval 20 feet.

Datum is mean sea level.

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